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The Effect of Monetary Policy on Exchange Rates during Currency Crises: the Role of Debt, Institutions, and Financial Openness*

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Abstract

This paper empirically examines the effect of monetary policy on exchange rates during currency crises. We find strong evidence that raising the interest rate: (i) has larger adverse balance sheet effects and is therefore less effective in countries with high domestic corporate short-term debt; (ii) is more credible and therefore more effective in countries with high-quality institutions; (iii) is more credible and therefore more effective in countries with high external debt; and (iv) is less effective in countries with high capital account openness. Our results support the idea that the effect of monetary policy depends on its impact on fundamentals, as well as its credibility, as suggested in the recent theoretical literature.

1. Introduction

The role of monetary policy during currency crises has gained attention, especially in the aftermath of the Asian crisis. The large depreciations in Thailand, Korea, Indonesia, and the Philippines in 1997 and 1998 had detrimental effects on corporate balance sheets and resulted in large-scale banking sector distress and economic downturn. An important question that has been subject to debates amongst policymakers and academics ever since, is whether higher interest rates can support the exchange rate during such crises.

The conventional view is that higher interest rates support exchange rates by discouraging capital outflows and increasing the costs of speculating against the currency. Higher interest rates can also signal the monetary authorities' commitment to support the exchange rate in the future (Drazen, 2003). The empirical literature, however, does not find a clear and systematic impact of monetary policy on exchange rates. Some studies find that tighter monetary policy appreciates the exchange rate, others find the opposite, while some fail to find any effect.[1] Most of these studies are based on particular countries and crisis episodes. Hence, the evidence seems to suggest that, if there is an effect of monetary policy on exchange rates during crises, it is likely to depend on country-specific circumstances.

A small but growing theoretical literature has started to investigate these circumstances by looking at the various channels through which higher interest rates affect exchange rates. Two types of arguments can be distinguished. First, higher interest rates affect exchange rates through their impact on economic fundamentals. They might, for

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example, weaken the financial system, increase public debt, and lead to a credit crunch. Depending on the magnitude of these adverse effects, raising interest rates could weaken the currency, rather than strengthen it.[2]

The second type of argument is suggested by Drazen (2003) and relates to the signaling of unobserved government characteristics. If raising interest rates is believed to signal the monetary authorities' commitment to supporting its currency, then it might be successful. However, if it is believed to signal weak fundamentals or panic at the monetary authorities, then the effect will be opposite.

The channels through which monetary policy affects the exchange rate have so far received little attention in the empirical literature. The only study that uses a large cross-section of currency crisis episodes and investigates the effect of monetary policy on exchange rates *during* those episodes is Goldfajn and Gupta (2003).[3] Using a dataset of crisis episodes in 80 countries, they find that tight monetary policy increases the probability that a real appreciation of the exchange rate occurs through a nominal appreciation rather than an increase in inflation, but only in countries with strong banking sectors.

This paper considers four new country-specific characteristics that could be important determinants of the effect of monetary policy *during* crises and empirically tests their importance. First, we look at *domestic short-term corporate debt*. Furman and Stiglitz (1998) argue that higher interest rates can increase the likelihood of corporate defaults by increasing debt service payments and compromising balance sheets. An increased likelihood of defaults will also lead to a higher risk premium. If these two effects, a higher default probability and a higher risk premium, more than offset the higher promised return, then higher interest rates cause further capital outflows and a weaker currency. Following Goderis and Ioannidou (2008), we argue that this monetary policy channel is likely to be more important for countries with high short-term corporate debt. The higher the level of debt, the larger the adverse effects of higher interest rates, and thus the larger the probability that higher interest rates depreciate the exchange rate.

Secondly, we consider the credibility of higher interest rates as a signal of the monetary authorities' commitment to supporting its currency. Our hypothesis is that the credibility of government policies, and thus also the credibility of monetary policy, increases with *the quality of a country's institutions*. Countries with a stable government, a strong rule of law, and a high-quality bureaucracy, will be better able to credibly commit. As a result, the same monetary policy decision might have different effects on the exchange rate, depending on the institutional setting within which it is taken.[4]

Thirdly, we consider *foreign currency denominated ("external") debt*. The recent theoretical "third-generation" or "balance sheet" currency crisis literature has stressed the importance of external debt, both as a determinant of crises and as a determinant of the costs of crises.[5] The effect of external debt on the interest rate–exchange rate relationship, however, has received less attention. Eijffinger and Goderis (2007) argue that high external debt increases the costs of a depreciation because of its effect on corporate balance sheets. As a result, monetary authorities have stronger incentives to support their currency, even if that is costly as well. Our hypothesis is that these stronger incentives contribute to the credibility of higher interest rates, as they make continued support of the currency more likely.

Finally, we investigate *capital account openness*. An alternative to raising interest rates that is sometimes advocated is the use of capital controls in order to limit capital outflows. Given that the monetary authorities' power is constrained by their foreign reserves and their willingness to keep interest rates at a high level for a long time, capital controls might make it more feasible for the authorities to support their currency. In countries with full capital account mobility, the intensity and sheer volume of speculation make it increasingly difficult for the monetary authorities to counterbalance it. Hence, our hypothesis is that monetary policy is less effective in countries with high capital mobility.

The rest of the paper is organized as follows. Section 2 describes methodology and data. Section 3 discusses the main estimation results. Section 4 describes various robustness checks, addresses concerns of endogeneity, and investigates the economic importance of our results. Section 5 concludes.

2. Methodology and Data

Following Kraay (2003), we define the onset of a currency crisis as a large nominal depreciation or devaluation preceded by a relatively fixed nominal exchange rate:

$$(i,t)|de_{i,t} > k_i \quad \text{and} \quad \overline{de}_{i,t} < \overline{k}_i, \tag{1}$$

where $de_{i,t}$ is the monthly percentage change in the nominal exchange rate *vis-à-vis* the anchor currency[6] in country i between periods t and $t-1$; k_i is the threshold determining the minimum size of the devaluation; $\overline{de}_{i,t}$ is the average absolute percentage change in the exchange rate in country i in the 12 months prior to t; and $\overline{k}_i$ is the threshold determining the maximum size of the allowable exchange rate volatility prior to the devaluation. Following Kraay (2003), k_i is set to 5% (10%) for OECD (non-OECD) countries, while $\overline{k}_i$ is set to 1% (2.5%) for OECD (non-OECD) countries. To prevent double-counting, we eliminate episodes that were preceded by episodes in the preceding 12 months. This procedure is applied to all countries for which we have data and yields a list of start dates. We identify the end as the first month after the start in which speculative pressures have substantially diminished compared to their earlier peaks: for crises starting in month t, we define endings as the first month $t+s$ ($s>0$) for which the following holds:

$$s_{i,t+s+j} < \overline{s}_{i,t} + 0.25 * (s_{i,t}^{MAX} - \overline{s}_{i,t}), \quad j = 0, 1, 2, \tag{2}$$

where $s_{i,t+s+j}$ is the nominal money market interest rate[7] spread over the US Federal Funds rate in country i and month $t+s+j$ where t and s denote the starting month and the length of the crisis, respectively. $\overline{s}_{i,t}$ is the average spread[8] in the 24 months preceding month t, and $s_{i,t}^{MAX}$ is the mean of the three highest levels of spreads in month t and the five succeeding months. In order to eliminate periods in which a relatively fixed exchange rate was abandoned without substantial financial turmoil, we exclude six periods for which the difference between $s_{i,t}^{MAX}$ and $\overline{s}_{i,t}$ does not exceed three percentage points, as they exhibit only a limited degree of speculative pressure.[9] This procedure yields a panel of 18 crisis episodes.[10] Using this panel, we analyze the effect of monetary policy on the exchange rate using the following specification:

$$Y_{i,t} = \beta_0 + \beta_1 X_{i,t-1} + \beta_2 Z_{i,t-k} + \beta_3 X'_{i,t-1} Z_{i,t-k} + \varepsilon_{i,t}, \tag{3}$$

where $Y_{i,t}$ is an indicator that captures the change in the exchange rate in month t for country i; $X_{i,t-k}$ is an indicator that captures changes in the stance of monetary policy; and $Z_{i,t-k}$ is a vector that includes episode-specific fundamentals that are expected to affect the exchange rate (e.g. international reserves, business cycle, etc.), where $k = 0, 1, \ldots, n$. Finally, the interaction term of $X_{i,t-1}$ and $Z_{i,t-k}$ captures how the effect of monetary policy changes for different levels of fundamentals. The interaction terms of monetary policy with domestic short-term corporate debt, institutional quality, external debt, and capital account openness are used to test the central hypotheses of the paper.

We use two indicators for the change in the exchange rate. The first, *NE*, captures the change in the *nominal* exchange rate and equals the percentage change in the monthly average local currency price of the German mark (US dollar) for European (non-European) countries (IFS, line rf). The second, *RE*, captures the monthly percentage change in the *real* exchange rate. The real exchange rate is constructed by adjusting the nominal exchange rate for domestic and German/US price levels (IFS, line 64).

As for the change in monetary policy, $X_{i,t-k}$, several measures have been proposed. Kraay (2003) uses the discount rate as it is largely controlled by the monetary authorities and therefore better proxies monetary policy than other interest rates. By contrast, Goldfajn and Gupta (2003) prefer money market interest rates, as discount rates often remain flat during interest rate defenses. Goderis and Ioannidou (2008) point out that the best available indicator of monetary policy is not necessarily the same across countries or time and therefore collect information on the most appropriate indicator for each of their sample episodes. In this paper we use two monetary policy indicators. Our preferred indicator, *MP*, is based on the country-specific interest rates collected by Goderis and Ioannidou (2008)[11] and is constructed as follows. We first collect daily data on the country-specific interest rates. We construct monthly averages of these series and express them as spreads over the anchor country's interest rates (Federal Funds rate for the US and discount rate for Germany). We then take the monthly percentage changes in these spreads and lag them by one month. Following Kraay (2003), our second indicator, *DISC*, is based on the discount rate (IFS, line 60) and is constructed in the same way as *MP*. Lagging the monetary policy indicator allows the transmission of monetary policy to take some time and limits concerns of reverse causality. For both measures of monetary policy we include the initial level of the spread as a control variable.

We next turn to the episode-specific fundamentals, $Z_{i,t-k}$. Six fundamentals are taken from Kraay (2003) and Goderis and Ioannidou (2008). First, as an indicator of real exchange rate overvaluation, we include the average percentage growth rate of the real exchange rate *vis-à-vis* the anchor country during the previous 12 months. An average real appreciation implies a loss of competitiveness and increases the likelihood of a depreciation to restore competitiveness. Secondly, we include nongold reserves as a percentage of total imports in the previous month (IFS, lines 1L.D and 71.D). Reserves can be used to support the exchange rate and hence higher reserves are expected to strengthen the currency. Thirdly, as an indicator of a country's external payments position, we include the average of a country's outstanding IMF loans as a percentage of its quota in the previous 12 months (IFS, lines 2TL and 2F.S). A high level of IMF loans might discourage investors to lend to a country or persuade those already present to leave, which depreciates the exchange rate. Fourthly, we include the deviation of real per capita GDP growth in the previous calendar year from the average of the five years before (*World Development Indicators*, WDI). Lower growth might lower international investors' expectations of future returns and might make it more difficult for a country to meet its external debt service obligations. Again, this could lead to a decrease in demand for the domestic currency, causing a depreciation. Finally, we include the monthly percentage change in real exports and imports in the previous month (IFS, lines 70.D and 71.D). Higher exports increase the supply of foreign currency which, everything else equal, appreciates the exchange rate. By contrast, higher imports increase demand for foreign currency and thus depreciate the exchange rate.

To test our central hypotheses, we also include measures of domestic short-term corporate debt, institutional quality, external debt, and capital account openness. For domestic short-term corporate debt, we follow Goderis and Ioannidou (2008) and collect data on short-term debt and total assets for a large number of publicly listed companies in developed and emerging markets from the Thomson Financial's Worldscope database. We construct an aggregate measure of a country's short-term debt by taking the mean of the individual short-term debt to total assets ratios in the calendar year before the year of the exchange rate change. To capture the quality of a country's institutions we use the *International Country Risk Guide* (ICRG) rating, which is a weighted index of 22 variables in three subcategories of risk: political (50%), financial (25%), and economic (25%). The index includes measures of, for example, the quality of a country's bureaucracy, the degree of corruption, the degree of democratic accountability, the stability of the government, and the degree of law and order. The index ranges from 0 for very bad institutions to 100 for very good institutions. As an indicator of a country's external debt position we use external debt over GDP, taken from the World Bank's *World Development Indicators*, in the calendar year before the year of the exchange rate change. External debt consists of all public, publicly guaranteed, and private nonguaranteed long-term debt, use of IMF credit, and short-term debt, owed to nonresidents and repayable in foreign currency, goods, or services.[12] Finally, we use the (updated) Chinn and Ito (2005) index as an indicator of capital account openness. This index was constructed using information on multiple exchange rates, current account transactions, capital account restrictions, and the requirement of the surrender of export proceeds, taken from the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions*.[13]

Table 1 reports summary statistics. On average, the nominal and real exchange rates depreciated during the episodes in our sample, while monetary policy on average tightened.[14] The standard deviation of *DISC* is lower than the standard deviation of *MP*, which is consistent with the argument above that discount rates tend to remain flatter than other monetary policy indicators.

3. Estimation Results

We performed Hausman tests, F-tests, and Lagrange multiplier tests to compare fixed effects, random effects, and pooled OLS estimation. The results did not reject the use of pooled OLS. Hence, Table 2 reports pooled OLS estimation results for six alternative specifications based on equation (3). Column (1) shows results when using the monetary policy indicator *DISC* and fundamentals but no interaction terms. Monetary policy enters with a positive sign, indicating that an increase in interest rates leads to a depreciation of the nominal exchange rate. This effect is statistically significant at 5% and supports the revisionist view that higher interest rates weaken the home currency during currency crises.

Four control variables enter with expected signs but only one is significant. External debt enters with a positive sign and is significant at 5%, indicating that higher external debt depreciates the exchange rate, which is consistent with the recent balance sheet crisis literature. Capital account openness enters with a positive sign and is significant at 1%, suggesting that higher openness depreciates the exchange rate. Exchange rate overvaluation enters with a negative sign, indicating that an overvalued exchange rate leads to a depreciation. Finally, the growth rate of exports enters with a negative sign, suggesting that higher exports appreciate the exchange rate. The other control variables do not have the expected signs.

Table 1. Summary Statistics

	Obs.	*Mean*	*Std. dev.*	*Min.*	*Max.*
Dependent variable					
NE	163	0.03	0.11	–0.24	0.45
RE	163	0.01	0.10	–0.23	0.41
Monetary policy					
MP	163	0.06	0.33	–0.87	2.04
DISC	123	0.03	0.17	–0.27	0.96
MP-domestic	163	0.03	0.24	–0.86	1.45
MP-foreign	163	–0.01	0.04	–0.24	0.09
Fundamentals					
Debt to total assets	163	0.18	0.09	0.04	0.45
Institutional quality	163	0.66	0.13	0.41	0.87
External debt	163	0.37	0.30	0.01	1.58
Capital account openness	163	0.07	1.00	–1.09	2.07
Exchange rate overvaluation	163	0.02	0.03	–0.04	0.14
Reserves to imports	163	6.22	4.56	0.68	22.14
External payments position	163	1.21	1.72	0.00	6.63
Deviation GDP growth	163	–0.02	0.05	–0.20	0.10
Exports growth	163	0.01	0.14	–0.71	0.43
Imports growth	163	–0.01	0.16	–0.52	0.54
Initial level of spread (*MP*)	163	0.25	0.42	0.05	4.60
Initial level of spread (*DISC*)	130	0.19	0.16	0.00	0.66

Note: This table reports summary statistics for all variables used in estimation.

Column (2) shows the results when using our preferred monetary policy indicator *MP*. We again find that an increase in interest rates depreciates the nominal exchange rate. This effect is somewhat smaller than before and statistically significant at 10%. The control variables enter with the same signs as before except for the level of the spread which is now positive and significant at 1%, indicating that higher levels of the spread correspond to nominal exchange depreciations. The coefficients of debt to total assets, external debt, capital account openness, and GDP growth are no longer significant.

In columns (3) and (4) we add interaction terms of monetary policy with all fundamentals except institutional quality to test whether the effect of monetary policy depends on these fundamentals. Three of the hypotheses in this paper—increasing the interest rate to support the exchange rate is less effective in countries with high domestic corporate short-term debt, low external debt, and high capital account openness—are tested using the interaction terms of monetary policy with (domestic corporate) short-term debt to total assets, external debt, and capital account openness.

Column (3) shows results when using the monetary policy indicator *DISC*. Monetary policy again enters positive but is no longer significant. Its interactions with short-term debt to total assets, external debt, and capital account openness all enter with the expected sign, confirming the hypotheses that monetary policy is less effective for higher short-term debt, lower external debt, and higher capital account openness. However, these effects are insignificant, except for the interaction of external debt, which is significant at 10%. The interaction terms of monetary policy with the other fundamentals all enter insignificant as well. This is consistent with Kraay (2003), who

Table 2. Estimation Results

	(1)	(2)	(3)	(4)	(5)	(6)
MP		0.05*		–0.23***	0.42*	0.43*
		(0.03)		(0.08)	(0.20)	(0.21)
DISC	0.14**		0.07			
	(0.05)		(0.15)			
Debt to total assets	–0.23**	–0.10	–0.30*	–0.14	–0.22	–0.24*
	(0.08)	(0.10)	(0.16)	(0.12)	(0.15)	(0.14)
Institutional quality					0.18	0.12
					(0.13)	(0.10)
External debt	0.10**	0.02	0.10*	0.02	0.09	0.05
	(0.04)	(0.04)	(0.05)	(0.04)	(0.07)	(0.04)
Capital account openness	0.02***	0.01	0.02**	0.01	0.01	0.01
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Exchange rate overvaluation	–0.35	–0.04	–0.30	–0.34	0.06	
	(0.24)	(0.23)	(0.31)	(0.38)	(0.24)	
Reserves to imports	0.00	0.00	0.00	0.00	0.00	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	
External payments position	–0.01	–0.00	–0.01	–0.00	–0.00	
	(0.02)	(0.00)	(0.02)	(0.00)	(0.00)	
Deviation GDP growth	0.45**	0.14	0.42	0.12	0.26	
	(0.17)	(0.21)	(0.24)	(0.23)	(0.24)	
Exports growth	–0.07	–0.06	–0.05	–0.06	–0.06	
	(0.04)	(0.04)	(0.06)	(0.05)	(0.04)	
Imports growth	–0.04	–0.06	–0.05	–0.05	–0.04	
	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	
Initial level of spread	–0.01	0.09***	–0.06	0.07***	0.10***	0.10***
	(0.09)	(0.01)	(0.11)	(0.01)	(0.02)	(0.01)
Monetary Policy × Debt to total assets			0.87	2.01***	1.18**	1.25**
			(1.09)	(0.63)	(0.45)	(0.43)
Monetary Policy × Institutional quality					–0.67**	–0.70**
					(0.27)	(0.28)
Monetary Policy × External debt			–0.83*	–0.34	–0.26*	–0.28*
			(0.43)	(0.26)	(0.13)	(0.13)
Monetary Policy × Capital account openness			0.04	0.08*	0.03*	0.03
			(0.06)	(0.04)	(0.01)	(0.02)
Monetary Policy × Exchange rate overvaluation			–0.72	1.16		
			(1.06)	(1.51)		
Monetary Policy × Reserves to imports			0.04	0.01*		
			(0.04)	(0.01)		
Monetary Policy × External payments position			0.05	–0.01		
			(0.23)	(0.01)		
Monetary Policy × Deviation GDP growth			–0.23	–0.12		
			(1.60)	(0.44)		
Monetary Policy × Exports growth			–0.88	–0.44		
			(0.74)	(0.79)		
Monetary Policy × Imports growth			0.74	0.81		
			(0.44)	(0.54)		
Number of observations	123	163	123	163	163	163
Adjusted R-squared	0.21	0.17	0.27	0.25	0.23	0.20

Notes: The dependent variable is *NE*. Robust standard errors are clustered by crisis episode and are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

also fails to find any evidence of a nonlinear effect of monetary policy. The fundamentals enter with the same signs as in column (1).

As argued by Goldfajn and Gupta (2003), discount rates often fail to reflect important changes in monetary policy. Moreover, using a universal monetary policy interest rate fails to recognize that different countries use different key interest rates as part of their monetary policy strategy. It is therefore interesting to investigate if and how our findings change when using our preferred country-specific monetary policy indicator *MP*. Column (4) shows the results. Monetary policy now enters negative and is statistically significant at 1%. Its interaction with short-term debt to total assets enters with the expected sign and is also significant at 1%. This indicates that monetary policy is more effective in countries with low levels of domestic corporate short-term debt. The interaction of monetary policy with capital account openness enters with the expected sign as well and is significant at 10%, suggesting that monetary policy is more effective in countries with low capital account openness. Finally, the interaction of monetary policy with external debt also enters with the expected sign but is not significant. The coefficients of the control variables are very similar to the coefficients in column (2). The remaining interaction terms all enter insignificant, except for the interaction of *MP* with the level of reserves.

We next consider institutional quality as a determinant of the efficacy of monetary policy. Column (5) reports the results when adding the interaction of monetary policy with institutional quality. The interaction terms other than the ones of interest are dropped due to multicollinearity. All four interaction terms enter with the expected signs and are all statistically significant. The interaction of monetary policy with short-term debt remains positive and enters significant at 5%, while the interaction of monetary policy with external debt remains negative but is now significant at 10%. The interaction of monetary policy with capital account openness again enters positive and is significant at 10%, although the coefficient is somewhat smaller. Finally, the interaction of monetary policy with institutional quality enters with a negative sign and is significant at 5%. This indicates that monetary policy is more effective in countries with good institutions. While monetary policy was negative and significant in column (4), it now enters positive and significant at 10%. The change in the coefficient of monetary policy shows that the negative and significant effect in column (4) can be attributed to the institutional quality and external indebtedness of countries. Once we control for these two variables, the coefficient of monetary policy changes sign. Institutional quality by itself enters positive but is not significant. The other regressors enter with the same signs and significance as in column (4), except for exchange rate overvaluation.

The goodness of fit in columns (1) to (5) is quite low, given the large number of regressors. In column (6) we therefore drop the six control variables that are insignificant. The results are very similar. Monetary policy as well as its interactions with the four fundamentals enter with the same sign, similar size, and the same level of significance as in column (5). The only exception is the interaction of monetary policy with capital account openness, which has the same coefficient but is no longer significant.

Summarizing, the results in Table 2 provide evidence that the efficacy of monetary policy in supporting the exchange rate during currency crises depends on a country's domestic corporate short-term debt, institutional quality, and external debt. Everything else equal, monetary policy is more effective in countries with lower corporate short-term debt, higher levels of institutional quality, or higher external debt. We also find some evidence that monetary policy is more effective in countries with low capital account openness.

4. Sensitivity Analysis

We next investigate the robustness of our results and address the endogeneity of monetary policy. First, we consider the interest rate spreads that we used to construct the monetary policy indicators in Table 2. Using these spreads allows us to eliminate changes in domestic monetary policy that result from monetary policy changes in the anchor country, i.e. the monetary policy changes that are not expected to affect the exchange rate but instead are aimed at keeping the exchange rate stable. However, this implies that in principle our results could be driven by either changes in the domestic interest rate or the anchor country's interest rate or by both. Since we are primarily interested in testing whether higher *domestic* interest rates support the exchange rate, it is important to investigate whether our results do indeed stem from domestic rather than foreign monetary policy changes. Hence, we separate our preferred monetary policy indicator *MP* into a domestic monetary policy indicator, which is the lagged percentage change in the monthly average of the *domestic* interest rate, and a foreign monetary policy indicator, which is the lagged percentage change in the monthly average of the *anchor country's* interest rate. Column (1) of Table 3 reports the results of the specification in Table 2, column (6), when replacing the monetary policy indicator *MP* with the domestic and foreign monetary policy indicators. The results are reassuring as they clearly show that the results in Table 2, column (6), are driven by domestic monetary policy. *MP*-domestic enters positive and is significant at 10%, which is consistent with *MP* in Table 2, column (6), while *MP*-foreign is not significant. Moreover, the interactions of *MP*-domestic with debt to total assets, institutional quality, external debt, and capital account openness all enter with the same signs and are all significant, while the same interactions for *MP*-foreign are all insignificant.

Table 3, column (2), tests whether our results are robust to the inclusion of a time trend. During crises, exchange rate depreciation is typically highest in early months and lower in later months. The negative and highly significant coefficient of the time trend confirms this. However, the coefficients for *MP* and the interactions of *MP* with the fundamentals of interest are very similar to column (6) of Table 2, and gain significance. The interactions of *MP* with debt to total assets and institutional quality are now significant at 1%, while the interaction of *MP* with capital account openness is significant at 5%. As an additional robustness check, we also investigated the possibility that the impact of monetary policy varies across crisis months but found no evidence that this is the case.

We next test the robustness of our results to the inclusion of the lagged dependent variable. The results are reported in Table 3, column (3). The lagged exchange rate change enters positive and is significant at 10%. The other coefficients are very similar to the ones in Table 2, column (6). Both *MP* and the interactions of *MP* with debt, institutions, and openness are significant, while the coefficient on the interaction of *MP* with external debt has a similar size but is now insignificant. Columns (4) to (7) repeat the specifications in Table 2, column (6), and Table 3, columns (1) to (3), but with the real instead of the nominal exchange rate change as the dependent variable. The results are very similar.

An econometric concern is that monetary policy could be endogenous, causing our estimates to be biased. Kraay (2003) and Goderis and Ioannidou (2008) use the percentage change in real reserves to instrument for monetary policy. However, this instrument is a rather poor predictor of monetary policy in our sample. In the absence of other strictly exogenous instruments, we use the system GMM estimator developed

Table 3. Estimation Results—Sensitivity Analysis

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Lagged exchange rate change			0.12*				0.10
			(0.06)				(0.09)
Time trend		–0.42**				–0.33**	
		(0.14)				(0.13)	
MP		0.42**	0.44*	0.36*		0.34*	0.37*
		(0.19)	(0.21)	(0.19)		(0.17)	(0.18)
MP-domestic	0.65*				0.55		
	(0.34)				(0.32)		
MP-foreign	0.29				–0.64		
	(1.61)				(1.19)		
Debt to total assets	–0.23	–0.19*	–0.21	–0.21	–0.22	–0.18	–0.20
	(0.16)	(0.11)	(0.14)	(0.13)	(0.17)	(0.11)	(0.14)
Institutional quality	0.13	0.17*	0.15	0.21*	0.23*	0.25**	0.22*
	(0.12)	(0.09)	(0.09)	(0.11)	(0.13)	(0.10)	(0.10)
External debt	0.05	0.06	0.05	0.07	0.07	0.08	0.07
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
Capital account openness	0.01	0.01	0.01	0.00	0.00	0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Initial level of spread	0.10***	0.10***	0.09***	0.09***	0.09***	0.09***	0.08***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
MP × Debt to total assets		1.16***	1.12**	1.27***		1.20***	1.15**
		(0.39)	(0.50)	(0.37)		(0.33)	(0.49)
MP × Institutional quality		–0.72***	–0.72**	–0.64**		–0.65**	–0.67**
		(0.24)	(0.29)	(0.27)		(0.24)	(0.26)
MP × External debt		–0.23*	–0.24	–0.23*		–0.19	–0.20
		(0.12)	(0.15)	(0.13)		(0.12)	(0.16)
MP × Capital account openness		0.03**	0.03*	0.03*		0.03**	0.03**
		(0.01)	(0.02)	(0.02)		(0.01)	(0.02)
MP-domestic × Debt to total assets	1.75**				1.84**		
	(0.72)				(0.62)		
MP-domestic × Institutional quality	–1.01**				–0.95*		
	(0.45)				(0.45)		
MP-domestic × External debt	–0.45*				–0.38		
	(0.24)				(0.24)		
MP-domestic × Capital account openness	0.08**				0.08**		
	(0.03)				(0.03)		
MP-foreign × Debt to total assets	1.17				0.26		
	(2.41)				(2.62)		
MP-foreign × Institutional quality	0.49				1.75		
	(1.68)				(1.46)		
MP-foreign × External debt	–0.64				–0.06		
	(2.75)				(2.36)		
MP-foreign × Capital account openness	0.56				0.45		
	(0.32)				(0.27)		
Number of observations	163	163	163	163	163	163	163
Adjusted R-squared	0.26	0.26	0.23	0.18	0.24	0.22	0.20

Notes: The dependent variable is *NE* in columns (1) to (3) and *RE* in columns (4) to (7). Robust standard errors are clustered by crisis episode and are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998). Arellano and Bond (1991) propose to first transform the model by first differencing to eliminate possible individual effects and then apply instrumental variables. In particular, endogenous variables in first differences are instrumented with suitable lags of their own levels and first differences. Arellano and Bover (1995) extended this difference-GMM estimator by adding the equations in levels to the system, creating what is often called the system-GMM estimator. Blundell and Bond (1998) show that exploiting the additional moment conditions of the system GMM provides dramatic efficiency gains.

We use system-GMM to address the endogeneity of all regressors, including the lagged dependent variable.[15] In the transformed equation we instrument regressors with lags of their own levels, while in the levels equation we instrument regressors with lags of their own differences. For example, we instrument monetary policy at time $t-1$ with levels and differences of monetary policy and the other regressors at time $t-2$. All other regressors are instrumented in the same way. The number of instruments can potentially grow large, which causes problems of overfitting and can weaken the Sargan test of instrument validity up to the point where it generates implausible good p-values of 1.00. Roodman (2006) suggests two steps to limit the instrument count. First, we only use instruments at $t-2$ and leave out all instruments beyond $t-2$. Secondly, we "collapse" the instrument set, which means that we create one instrument for each variable and lag distance, rather than one for each time period, variable, and lag distance.

Table 4, column (1), reports the system-GMM results for the specification in Table 2, column (6). The results strongly confirm our earlier results. Monetary policy and its interactions with short-term corporate debt, institutional quality, external debt, and capital account openness all enter with the expected signs and are now all significant at 1%. The p-value of the Sargan test of instrument validity is 0.71, which indicates that the null of valid instruments cannot be rejected. Finally, at the bottom of column (1) we report the test statistics for the Arellano–Bond AR(1) and AR(2) tests of serial correlation in the error terms. If the error terms in the untransformed model are serially uncorrelated, then the differenced error terms in the differenced model should show negative first-order serial correlation and no second-order serial correlation. The Arellano–Bond AR(2) test statistic is negative but far from significant, suggesting the absence of substantial serial correlation in the error terms of the untransformed model. This is important as it supports the assumption that, even if lagged levels of the regressors are endogenous, i.e. correlated with the corresponding lagged error terms, they are not correlated with the contemporaneous error terms.

Table 4, column (2), reports results when adding the lagged dependent variable, which again enters positive and is significant at 10%. The results for monetary policy and its interactions are similar to column (1), although the interaction with external debt is now only significant at 10%. Debt to total assets and institutional quality are now significant but have the counterintuitive sign. External debt is significant at 10% and enters with the expected sign. The Sargan test again does not reject the null of valid instruments. However, the p-value is now quite high, which could be due to overfitting. The AR tests again indicate the absence of serial correlation in the error terms of the untransformed model.

Columns (3) and (4) repeat the specifications in (1) and (2) but with the *real* rather than the *nominal* exchange rate change as the dependent variable. As before, results are strongly robust.

Finally, we experiment with an alternative measure of external debt. A depreciation of the exchange rate inflates the local currency value of all foreign currency denominated debt on balance sheets, regardless of its maturity. However, this balance sheet deterioration might be more problematic for short-term external debt, as this needs to be repaid or rolled over much sooner. Given that crises typically do not last longer than two to three years, monetary authorities might be more concerned about short-term than about total external debt. To investigate this possibility, we re-estimate the specifications in Tables 2 to 4, using short-term external debt instead of total external debt.[16]

Table 4. Estimation Results—System GMM Estimation

	(1)	(2)	(3)	(4)
Lagged exchange rate change		0.16*		0.12
		(0.08)		(0.10)
MP	0.48***	0.51**	0.42***	0.46***
	(0.18)	(0.21)	(0.16)	(0.17)
Debt to total assets	–0.35	–0.53*	–0.42	–0.55**
	(0.38)	(0.28)	(0.33)	(0.24)
Institutional quality	0.00	0.33**	0.31	0.54***
	(0.21)	(0.14)	(0.23)	(0.14)
External debt	0.02	0.11*	0.08	0.14**
	(0.09)	(0.06)	(0.08)	(0.06)
Capital account openness	–0.02	–0.03	–0.02	–0.03
	(0.02)	(0.04)	(0.02)	(0.04)
Initial level of spread	0.09***	0.08***	0.09***	0.08***
	(0.02)	(0.02)	(0.01)	(0.02)
$MP \times$ Debt to total assets	1.87***	1.78***	1.78***	1.71***
	(0.32)	(0.53)	(0.35)	(0.55)
$MP \times$ Institutional quality	–0.86***	–0.93***	–0.80***	–0.88***
	(0.24)	(0.30)	(0.22)	(0.25)
$MP \times$ External debt	–0.43***	–0.38*	–0.36***	–0.34*
	(0.15)	(0.20)	(0.13)	(0.18)
$MP \times$ Capital account openness	0.05***	0.05***	0.04***	0.04***
	(0.01)	(0.01)	(0.01)	(0.01)
Number of observations	163	163	163	163
Number of crisis episodes	16	16	16	16
Number of instruments	20	22	20	22
p-Value Sargan test	0.71	0.94	0.54	0.87
Arellano and Bond AR(1) test	–1.55	–2.03**	–1.60	–2.20**
Arellano and Bond AR(2) test	–0.74	0.12	–0.78	–0.05

Notes: The dependent variable is *NE* in columns (1) and (2) and *RE* in columns (3) and (4). Robust standard errors are clustered by crisis episode and are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively. System GMM refers to the Arellano–Bover (1995)/Blundell–Bond (1998) one-step system GMM estimator. Forward orthogonal deviation transformation is used to eliminate fixed effects. To limit the number of instruments, the instrument sets are collapsed and only the first lags are used in the transformed and the levels equation.

Our results are strongly robust. In the specifications with *MP* and the interaction of *MP* with short-term external debt, the latter always enters with a negative sign and is now always significant at 5%, while significant at 1% for all specifications in Tables 3 and 4. Short-term external debt always enters positive and is significant at 10% in two specifications. Our results for the other interaction terms go through and in some cases also gain significance.

Summarizing, our sensitivity analysis shows that the nonlinear effects of monetary policy with respect to corporate short-term debt, institutions, and capital account openness are robust to the separation of monetary policy in its domestic and foreign components, the inclusion of a crisis-specific time trend or lagged dependent variable, and the use of system-GMM. The results for the interaction of monetary policy with external debt are slightly less robust, although it enters with the expected sign and is always significant in the system-GMM estimations. Moreover, when using *short-term* instead of *total* external debt, the interaction term is always significant. These results strongly support the central hypotheses of this paper. The impact of higher interest rates on exchange rates during currency crises depends importantly on a country's short-term corporate debt, institutional quality, external debt, and capital account openness.

We next investigate the economic relevance of these results, using the results in Table 4, column (1), by calculating the marginal effects of monetary policy for different levels of fundamentals. Panels (A) to (D) in Figure 1 illustrate these marginal effects for different levels of short-term corporate debt, institutional quality, external debt, and capital account openness, when evaluating the other three at their median. The ranges of levels for debt, institutions, external debt, and capital account openness correspond to the ranges in our sample. The solid lines represent the marginal effects, the dashed lines represent the 95% confidence interval. The upward-sloping solid line in panel (A) shows how the marginal effect of monetary tightening increases with debt. For the lowest debt levels, the marginal effect is negative and significant, indicating that raising the interest rate appreciates the exchange rate. For higher debt levels (above 0.13) the effect becomes positive, implying that raising the interest rate depreciates the exchange rate. For debt levels above 0.14, this effect is statistically significant at 5%. For most debt levels, this effect is also economically relevant. For example, the marginal effect of an interest rate increase in countries with a sample average debt level of 0.18, is equal to 0.09. This means that raising the interest rate change by one percentage point leads to an increase in the nominal depreciation by 0.09 percentage points.

Panel (B) shows the same graph for institutional quality. The downward-sloping solid line shows how the marginal effect of higher interest rates decreases for higher levels of institutional quality. For levels of institutional quality up to 0.74, raising interest rates depreciates the exchange rate, while for very high levels the effect changes sign and higher interest rates appreciate the exchange rate. The latter effect is significant at 5% for institutional quality above 0.84. Again, for most levels of institutional quality, the marginal effect is economically relevant. For a country with average institutions of 0.66, raising the interest rate change by one percentage point depreciates the exchange rate by an additional 0.08 percentage points.

Panel (C) shows how the marginal effect decreases for higher external debt levels. The graph differs from the others as for most of the external debt levels, the marginal effect of monetary policy is negative, i.e. raising interest rates appreciates the exchange rate. However, almost all observations in our sample are located within the left half of the graph. The right half of the graph contains only one observation: the maximum external debt level in our sample (1.58) which corresponds to Indonesia in 1998. Looking at the left half of panel (C) only, the marginal effect is again positive for most external debt levels and only turns negative for external debt levels above 0.45. For the median external debt level of 0.33, raising the interest rate by one percentage point depreciates the exchange rate by an additional 0.05 percentage points.

The upward-sloping solid line in panel (D) shows that the marginal effect of monetary policy increases with capital account openness and is always positive. For mean openness of 0.07, raising the interest rate by one percentage point depreciates the exchange rate by an additional 0.06 percentage points.

Finally, we use the results in Table 4, column (1), to predict the marginal effects of higher interest rates in each of our crisis episodes. Panel (E) shows the results. The marginal effect is negative in six crisis episodes and positive in all others. In five of these six crisis episodes, the marginal effect is also significant at 5%: Finland (1991), Philippines (1997), Slovakia (1998), South Africa (1998), and Venezuela (1995). This suggests that

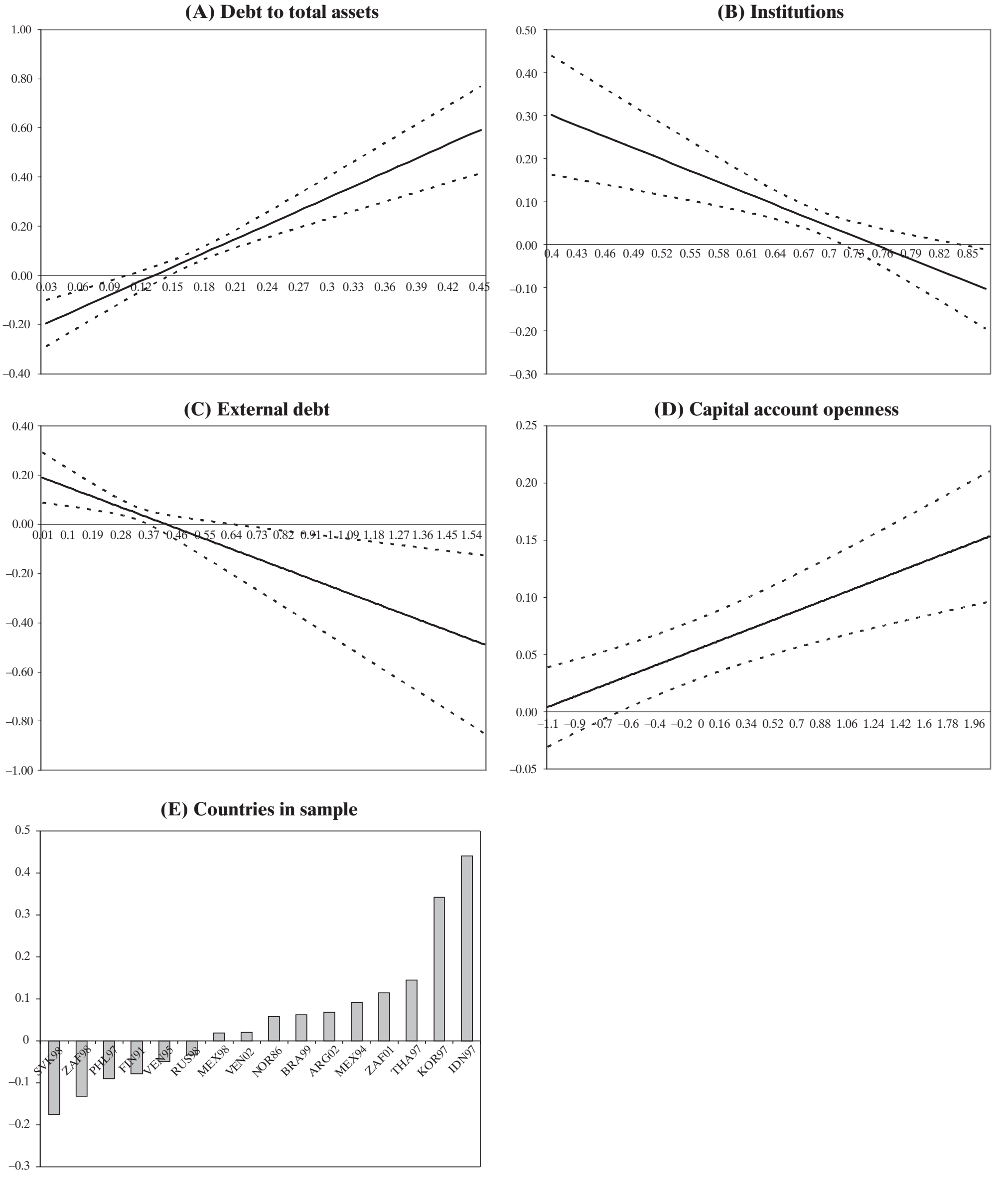

Figure 1. Marginal Effect of an Interest Rate Increase for Different Levels of Debt, Institutions, External Debt, and Capital Account Openness

Notes: Figure 1 is based on Table 4, column (1). Panels (A) to (D) show the marginal effects of an increase in *MP* for different levels of each of the four fundamentals, when evaluating the other three at the median. Panel (E) shows the predicted marginal effect during each of the crisis episodes, using the episode-specific median levels of the four fundamentals. A value of 0.20 on the vertical axis indicates that raising *MP* by 1% point leads to an increase in *NE* of 0.20% point.

during these episodes tighter monetary policy to support the exchange rate would have been effective. For four episodes, the predicted marginal effect of higher interest rates is not significant: Mexico (1998), Norway (1986), Russia (1998), and Venezuela (2002). And for all other episodes, raising the interest rate is expected to depreciate the exchange rate: Argentina (2002), Brazil (1999), Indonesia (1997), Korea (1997), Mexico (1994), South Africa (2001), and Thailand (1997). The result that monetary policy is counterproductive in the majority of episodes, is consistent with the positive and significant coefficient in Table 2, column (2), where we did not control for nonlinear effects.

5. Conclusions

This paper has examined four new country-specific characteristics that could be important determinants of the effect of monetary policy on exchange rates during currency crises. We tested four central hypotheses: (i) raising the interest rate has larger adverse balance sheet effects and is therefore less effective in countries with high domestic corporate short-term debt; (ii) raising the interest rate is more credible and therefore more effective in countries with high-quality institutions; (iii) raising the interest rate is more credible and therefore more effective in countries with high external debt; and (iv) raising the interest rate is less effective in countries with high capital account openness. Using data for currency crisis episodes between 1986 and 2004, we find strong and robust evidence to support our hypotheses. Using our estimation results, we predict that monetary policy would have had the conventional supportive effect on the exchange rate during five of the crisis episodes in our sample, while it would have had the perverse effect during seven other episodes. For four episodes, we predict a statistically insignificant effect. Our results support the idea that the effect of monetary policy depends on its impact on fundamentals, as well as its credibility, as suggested in the recent theoretical literature. They also provide an explanation for the mixed findings in the empirical literature.

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Notes

1. See for example Furman and Stiglitz (1998), Dekle et al. (2002), Goldfajn and Baig (2002), Goldfajn and Gupta (2003), Kraay (2003), Zettelmeyer (2004), and Caporale et al. (2005).
2. See for example Drazen and Masson (1994) and more recently Furman and Stiglitz (1998), Lahiri and Végh (2003, 2007), and Flood and Jeanne (2005).
3. Other studies investigate whether high interest rates defend currencies during speculative attacks. While Kraay (2003) finds no significant effects, Goderis and Ioannidou (2008) find that for low levels of corporate short-term debt, raising interest rates lowers the probability of crisis, while for higher debt this effect decreases and eventually reverses.
4. The role of institutions has recently gained attention in the crisis literature. Shimpalee and Breuer (2006) find strong evidence that corruption, government instability, and a lack of law and order increase the probability of a crisis.
5. See for example Schneider and Tornell (2004).
6. Historically, European countries typically pegged to the German mark whereas non-European countries often pegged to the US dollar. Hence, we use the monthly average local currency price of the German mark for European countries and the local currency price of the US dollar for all other countries (*International Financial Statistics* (IFS) line rf).
7. IFS line 60b.
8. We exclude months that lie more than two standard deviations above the mean, in order not to count episodes of distress related to the upcoming crisis.
9. Denmark 1993, Ireland 1993, Korea 2000, Spain 1995, Sweden 1992, and United Kingdom 1992.

10. Argentina 2002:1–2002:10, Brazil 1999:1–1999:5, Finland 1991:11–1993:2, Indonesia 1986:9–1989:2 and 1997:8–1999:6, Ireland 1986:8–1987:5, Korea 1997:11–1998:7, Mexico 1994:12–1996:8 and 1998:9–1999:4, Norway 1986:5–1988:8, Philippines 1997:9–1997:12, Russia 1998:9–1998:11, Slovakia 1998:10–1999:12, South Africa 1998:7–1999:3 and 2001:12–2004:6, Thailand 1997:7–1998:7, and Venezuela 1995:12–1996:6 and 2002:2–2003:7. We used nongold reserves as an indicator of speculative pressure for Slovakia and Venezuela (1995–96). Slovakia (1993:7) was excluded since it was due to the separation of Czechoslovakia.
11. See Table 2 in the working paper version (Goderis and Ioannidou, 2006). For Ireland we use the discount rate, identified from the central bank website. The data source is Datastream.
12. For Finland (1991) and Norway (1986) data are from IFS. For Korea (1997) data are from McLeod and Garnaut (1998).
13. We thank Menzie Chinn and Hiro Ito for making this index available.
14. We dropped January 1998 for Indonesia from our sample as the nominal and real exchange rate depreciation in this episode (96.8% and 84.5%, respectively) represent an outlier.
15. We use the xtabond2 procedure in Stata (Roodman, 2005).
16. Short-term external debt was taken from WDI and includes all debt having an original maturity of one year or less and interest in arrears on long-term debt. For Finland (1991), Korea (1997), and Norway (1986), we multiply total external debt by the domestic corporate short-term debt to total debt ratios.